APPLICATION NO. 10/772,597

INVENTION: Decisioning rules for turbo and convolutional decoding

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Currently amended CLAIMS

CLAIMS

WHAT IS CLAIMED IS:

Claim **1.(**currently amended) A ~~means~~ method for ~~the~~ performing a new turbo decoding algorithm using a-posteriori probability $p(s,s'|y)$ in equations **(13)** ~~of the invention disclosure of the decoder trellis states s',s for the received codeword k-1,k conditioned on the received symbol set y = {y(1),y(2),. . .,y(k-1),y(k),. . .,y(N)}~~ for defining the maximum a-posteriori probability MAP, comprising: ~~in turbo decoding and which comprises~~:

using a new statistical definition of the MAP logarithm likelihood ratio $L(d(k)|y)$ in equations **(18)**

$$L(d(k))|y) = \ln[\ \Sigma_{(s,s'|d(k)=+1)}\ p(s,s'|y)] - \ln[\ \Sigma_{(s,s'|d(k)=-1)}\ p(s,s'|y)\ ]$$

equal to the natural logarithm of the ratio of the a-posteriori probability $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=1$ to the $p(s,s'|y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=0$,

using a factorization of the a-posteriori probability $p(s,s'|y)$ in equations 13 into the product of the a-posteriori probabilities ~~p(s'|y(j<k)),p(s|s',y(k)), p(s|y(j>k))~~

$$p(s,s'|y)=p(s|s',y(k))p(s|y(j>k))p(s'|y(j<k)),$$

using a turbo decoding forward recursion equation ~~for evaluating said a-posteriori probability p(s'|y(j<k)) using said p(s|s',y(k)) as the state transition a-posteriori probability of the trellis~~

$$p(s|y(j<k),y(k)) = \sum_{all\ s'} p(s|s',y(k))\ p(s'|y(j<k))$$

for evaluating said a-posteriori probsbility $p(s'|y(j<k))$ in equations 14 using $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1 and given the observed symbol $y(k)$ to update these recursions for the assumed value of the user data bits $d(k)$ equivalent to the transmitted symbol $x(k)$ which is the modulated symbol corresponding to $d(k)$,

using a turbo decoding backward recursion equation ~~for evaluating said a-posterior probability p(s|y(j>k)) using said p(s'|s,y(k)) as the state transition a-posteriori~~

$$p(s'|y(j>k-1) = \sum_{all\ s} p(s|y(j>k))p(s'|s,y(k))$$

for evaluating the a-posterior probability $p(s|y(j>k))$ in equations 15 using said $p(s'|s,y(k)) = p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition pa ~~equivalent to said transmitted symbol x(k) which is the modulated symbol corresponding to said d(k) and where said p(s'|s,y(k))=p(s|s',y(k)),~~

evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k))=p(s'|s,y(k))$ ~~as a function which is linear in the received symbol y(k)~~equal to the new decisioning metric DX in equations 11,16, defined by equation

$\ln[p(s|s',y(k))$ $= \ln[p(s'|s,y(k))]$

$= \mathrm{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))$

$= DX$

~~and~~ wherein $\underline{p}$ is the natural logarithm ln of p, x* is the comp~~o~~lex conjugate of x, and ln[o] is the natural logarithm of [o]~~;~~

~~evaluating said natural logarithm of said state transition a-posteriori probability p(s'|s,y(k))=p(s|s',y(k)) equal to the new decisioning metric DX in equations **(11),(16)**~~

$\cancel{\ln[p(s|s',y(k))] = \ln[p(s'|s,y(k))]}$

$\cancel{= \mathrm{Re}[y(k)x^*(k)]/\sigma^2 + |x(k)|^2/2\sigma^2 + \underline{p}(d(k)}$

$\cancel{= DX}$

~~and which is linear in said received symbol y(k),~~

whereby said new state transition probabilities in said MAP equations use said DX linear in y(k) in place of the current use of the maximum likelihood decisioning metric DM=[$-|y(k) - x(k)|^2/2\sigma^2$] which is a quadratic function of y(k),

$\cancel{DM = [\ -|y(k) - x(k)|^2/2\sigma^2\ ],}$

~~which is a quadratic function of y(k),~~

whereby said MAP turbo decoding algorithms ~~realizes~~ provide some ~~-~~of the performance improvements demonstrated in FIG. **5,6** using said DX, and~~,~~

~~said~~ whereby this new a-posteriori mathematical framework enables said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said y(k).

Claim **2.** (currently amended) ~~Wherein in claim 1 a~~A method for performing ~~means for said~~ a new convolutional decoding algorithm ~~in said~~using the MAP a-posteriori probability $p(s,s'|y)$ ~~and which comprises~~in equations 13, comprising::

using a new maximum a-posteriori principle which maximizes the a-posteriori probability $p(x|y)$ of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability $p(y|x)$ of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

using ~~said~~ the factorization of ~~said~~ the a-posteriori probability ~~-~~$p(s,s'|y)$ in equations 13 into the product of said a-posteriori probabilities $p(s'|y(j<k))$, $p(s|s',y(k))$, $p(s|y(j>k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$
\begin{aligned}
p_k(s|s') &= p(s|s',y(k)) \\
b_k(s) &= p(s|y(j>k)) \\
a_{k-1}(s') &= p(s'|y(j<k)),
\end{aligned}
$$

using a convolutional decoding forward recursion equation in equations 14 for evaluating said a-posteriori probability $a_k(s)=p(s|y(j<k),y(k))$ using said $p_k(s|s')=p(s|s',y(k))$ as said state transition probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at k-1,

using a convolutional decoding backward recursion equation in equations 15 for evaluating said a-posteriori probability $b_k(s)=p(s|y(j>k))$ using said $p_k(s'|s)=p(s'|s,y(k))$ as said state transition probability

of the trellis transition path s→s′ to the new state s′ at k-1 from the previous state s at k,

evaluating the natural logarithm of said state_transition a-posteriori_probabilities

$$\ln[p_k(s'|s)] = \ln[p(s'|s,y(k))]$$
$$= \ln[p(s|s',y(k))]$$
$$= \ln[p_k(s|s')]$$
$$= DX$$

equal to ~~said~~ the new decisioning metric DX in equations 16, and~~,~~

implementing said convolutional decoding algorithms to ~~realize~~obtain some of the~~—~~performance improvements demonstrated in FIG. **5**,**6** using said DX.

Claim **3**. (currently amended) Wherein_in claim ~~**1**~~**2** ~~A means fora~~ a method for implementing the new convolutional decoding recursive equations, ~~which calculate said MAP a-posteriori probability p(s,s′|y)~~ said method comprising: ~~and which comprises:~~ ~~said~~ implementing in equations 14 a forward recursion equation for evaluating ~~said~~the natural logarithm, $\underline{a}_k$, of a_k using ~~said p_k=ln[p(s|s′,y(k))] as~~ the natural logarithm ~~said~~ of the state transition a-posteriori probability $\underline{p}_k=\ln[p(s|s',y(k))]$ of the trellis transition path s′→s to the new state s at k from the previous state s′ at k-1, which is equation ~~and is~~

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + \underline{p}_k(s|s')]$$
$$= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')]$$
$$= \max_{s'} [\underline{a}_{k-1}(s') + Re[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]$$

wherein said $DX(s|s')=\underline{p}_k(s|s')]=\underline{p}_k(s'|s)=DX(s'|s)=DX$ is ~~said~~ the new decisioning metric, and ~~said~~ implementing in equations 15 a backward recursion equation for evaluating ~~said~~ the natural logarithm, b_k. of b_k using ~~said $p_k=\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$ as~~ the natural logarithm of said state transition a-posteriori probability $\underline{p}_k=\ln[p(s'|s,y(k))]=\ln[p(s|s',y(k))]$ of the trellis transition path $s\rightarrow s'$ to the new state s' at $k-1$ and is equation

$$\underline{b}_{k-1}(s') = \max_{s} [\underline{b}_k(s) + DX(s'|s)]$$. ~~and,~~

~~said decoding algorithms realize some of the performanceimprovements demonstrated in FIG. **5,6** using said DX.~~